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FOOD SAFETY : Perspectives and Challenges

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FOOD SAFETY : PERSPECTIVES AND CHALLENGES

ABSTRACT

FOOD SAFETY is a major concern for consumers, food producers, processors and regulatory agencies. It is concerned with ensuring food that is safe or free from disease causing agents such as microorganisms, biological toxins and chemicals from the **FARM TO THE TABLE**, or throughout the **FOOD CHAIN**. In the last decade, incidents of food-related disease outbreaks, such as Bovine Spongiform Encephalopathy (BSE), Foot and Mouth Disease (FMD), Febrile Encephalitis (Nipah Virus), Dioxin contamination of animal feeds, *Staphylococcus aureus* enterotoxin in snow-brand milk powder and Influenza virus in poultry (Hong Kong), have caused significant economic losses and attracted a lot of media attention. These outbreaks lead to human illness, deaths, destruction of livestock, closure of farms and processing plants resulting in losses amounting to billion of dollars.

Foodborne diseases are widespread and of growing public health concern problem, both in developed and developing countries. The Center for Disease Control (CDC), USA, estimates about 250 different foodborne pathogens. The global incidence of foodborne disease is difficult to estimate, but it has been reported that in the year 2000 alone, 2.1 million people died from diarrhoeal diseases. The latest edition of the WHO Quarterly Statistics indicates that, the incidence of foodborne diseases may be 300-350 times more frequent than those reported. About 1.5 billion global episodes of diarrhea occur annually, mainly in developing countries, resulting in 3 million deaths among children less than 5 years of age. The WHO estimates that 70% of diarrhoeal episodes are caused by biologically contaminated food. Epidemiological data from both developed and developing countries indicates that the incidence of food poisoning is on the increase. This increase can be attributed to globalization, changing life styles, urbanization, demographic changes, increase international trade and tourism, microbial adaptation, technology and innovation in food processing, food handling, marketing and retail. Changes in Agricultural practices such as intensive farming, use of pesticides, growth hormones and antibiotics have also contributed to the increase in the incidence of food poisoning and the emergence of food pathogens.

In addition to human suffering, caused by foodborne diseases in terms of death and ill-health, substantial economic costs are involved, affecting individuals, families, industries, health care systems and entire communities. At the national level, epidemics of foodborne disease affect tourism, trade and economic development.

INTRODUCTION

Food Safety is a major concern for consumers, food producers and processors and regulatory agencies. It is concerned with ensuring that food is safe or free from disease causing agents such as microorganisms, biological toxins and chemicals from the **FARM TO THE TABLE** or throughout the **FOOD CHAIN**. Food producers and processors strive very hard to provide safe food by adopting Good Agricultural Practices (GAPs), Good Manufacturing Practices (GMPs) and continuously monitoring on-line quality, to maintain their reputation and preserve market share. The regulatory agencies by means of legislation, surveillance, inspection and education strive to ensure that safe food is provided from farm to table.

Consumers demand food that is safe, wholesome and nutritious. Discerning consumers do not only demand food that is safe, wholesome and nutritious but consistent in quality with sensory and physical attributes such as taste, color, texture, flavor and aroma that should be similar to the fresh food. Ensuring food safety is a complex and difficult task as the food chain is long with many vulnerable nodes or links. The food chain is an extensive network of activities and can be divided into six stages: production (at the farm), processing or manufacturing, distribution, retailing and households. Each of this stage can be considered as independent or linked to each other as food from one stage to another have to be stored and transported from one stage to another. At each of these stages different strategies have to be formulated to ensure food safety. Food undergoes many transformations from production till it is serve on the dining table.

Epidemiological data from both developing and industrialized countries indicates that the incidence of food poisoning is on the increase. Industrialization does not mean that you reduce the risks of food poisoning as you introduce new variables, processes and lengthen the food chain. Many factors have contributed to the increase in foodborne disease. Urbanization and changing lifestyles has revolutionalized the food supply system, resulting in mass production and an explosive increase in the number of food service establishment and food outlets.

Mass production, environmental factors, and inadequate knowledge on the part of the food handlers have contributed to increased contamination of primary foodstuffs. The increase international trade has increased the risk for cross-border transmission of infectious diseases. Food, a major trade commodity while offering many benefits and opportunities, also presents new risks. As food production, manufacturing and marketing are now global, infectious agents can be disseminated from the original point of processing and packaging to locations thousands of miles away. Currently, world food trade is valued at US$500 billion per year and is expected to grow every year.

Increased trade in food, international travel, migration, economic and technological developments have changed dietary habits. New foods and preparation techniques together with dietary habits are introduced into different regions, and consequently, foodborne disease are emerging or reemerging. Dietary habits are also changing as a result of nutritional recommendations and campaigns or may be influence by food policy, production systems, or environmental changes that lead to increased access to certain foods. In the U.S.A., for example, public information campaigns on the health benefits of fruits and vegetables in the diet have lead to the increase consumption of fruits and vegetables. To meet this increased demand, these products have to be imported on a seasonal basis. At certain times of the year more than 75% of the fresh fruits and vegetables available in the grocery stores and restaurants are imported. Epidemiologic data have shown that, partly as a consequence of the increased consumption of fruits and vegetables, the proportion of foodborne disease outbreak has doubled.

In the U.S.A., which has one the best infrastructure to ensure food safety, it is estimated that as many as 9000 deaths and 6.5 to 33 million illness each year are of food related. The United States Department of Agriculture estimates that medical costs and productivity losses for 7 specific pathogens range between US$6.5 billion and US$34.9 billion annually. Total costs for all foodborne illness are likely to be much higher. The estimates do not include the total burden placed on society by the chronic illness caused by some foodborne pathogens.

In the last decade, incidents of food-related disease outbreaks, such as Bovine Spongiform Encephalopathy (BSE), Foot and Mouth Disease (FMD), Febrile Encephalitis (Nipah Virus), Dioxin contamination of animal feeds, *Staphylococcus aureus* enterotoxin in Snow Brand milk powder (Japan) and Influenza virus in poultry (Hong Kong), have caused significant economic losses and attracted a lot of media attention. These outbreaks lead to human illness, deaths, destruction of livestock, closure of farms and processing plants resulting in losses amounting to billion of dollars.

Definition of Foodborne Illness: Foodborne illness is defined as any disease usually infectious or toxic in nature caused by agents that enter the body through the ingestion of food or water. Every person is at risk of foodborne illness.

Magnitude of Foodborne Illness: Foodborne diseases are widespread and of growing public health problem, both in developed and developing countries. The United States Center for Disease Control and Prevention (CDC) has estimated about 250 different foodborne pathogens. Many pathogens, including *Salmonella, E. coli* 0157:H7, *Campylobacter*, and *Yersinia enterocolitica*, have reservoirs in healthy food animals, from which they spread to an increasing variety of foods

INCIDENCES OF FOOD POISONING

The global incidence of foodborne diseases is difficult to estimate, but it has been reported that in year 2000 alone, 2.1 million died from diarrhea disease. A great proportion of these cases can be attributed to contamination of food and drinking water(WHO). Additionally, diarrhea is a major cause of malnutrition in infants and young children. The latest edition of the WHO Quarterly Statistics indicates that the incidence of foodborne diseases may be 300 –350 times more frequent than those reported (World Health Quarterly Statistic, Vol.50, N $^1/_2$, WHO, Geneva, Switzerland).

Foodborne illness associated with microbial pathogens or other food contaminants are a serious health threat in developing and developed countries. Outbreaks of such illness can spread rapidly and transnationally, and disproportionately affect children and the elderly. About 1.5 billion global episodes of diarrhea occur annually, mainly in developing countries, resulting in 3 million deaths among children less than 5 years of age. The World Health Organization(WHO) estimates that 70% of diarrheal episodes are caused by biologically contaminated food.

The food production chain has become more complex, providing greater opportunities for contamination and growth of pathogens. Many outbreaks of foodborne diseases that were once contained within a small community may now take on global dimensions. In spite of safe water supplies, sound standards of hygiene and application of technologies such a pasteurization, a number of industrialized countries have experienced an increase in the incidence of foodborne diseases in recent years and the percentage of people suffering from foodborne diseases each year has being reported to be up by 30%. WHO estimates that in industrialized countries, less than 10% of foodborne illness cases are reported, while in developing countries probably less than 1% is reported. Surveys indicate that no less than 5-10% of the populations are involved annually. While most foodborne diseases are often sporadic, and often not reported, foodborne disease outbreaks may take on massive proportions. For example, in 1994, an outbreak of salmonellosis due to contaminated ice cream occurred in the USA, affecting an estimated 224,000 persons. In 1988, an outbreak of hepatitis A, resulting from consumption of contaminated clams, affected some 300,000 individuals in China.

In 1985 Archer and Kvenberg estimated that in the USA, 8.9 million foodborne illnesses are caused by known pathogens, whereas, 24 to 81 million foodborne illnesses are due all pathogens. In another study, Bennet *et al.* (1987) after reviewing the incidence figure for all known infectious diseases and by determining the proportion of each due to various modes of transmission concluded that foodborne transmission of known pathogens caused 6.5 million illness and up to 9000 deaths each year. In 1994, a task force convened by the Council for Agricultural Science and Technology (CAST, 1994) reviewed available studies and estimated the overall number of food-related illness at 33 million cases per year (Anon, 1994). Recently, Mead *et al.* (1999) after reviewing data from multiple sources (for example FoodNet, and National Notifiable Disease Surveillance System) and using a multiplier of 38 and 20 for pathogens that cause non-bloody diarrhea and bloody diarrhea respectively, concluded that each year both known and unknown foodborne pathogens cause 76 million human illness, 325,000 hospitalizations and 5,200 deaths. They further concluded that know pathogens cause 13.8 million illnesses, 60,854 hospitalization and 1809 deaths, whereas 62 million illnesses, 263,000 hospitalizations and 2400 deaths are due to unknown pathogens. They also observed that three pathogens *Salmonella, Listeria* and *Toxoplasma,* are responsible for 1500 deaths each year. They also observed that among cases of foodborne illness due to known agents, Norwalk-like viruses accounted for over 67% of all cases, 33% of hospitalizations and 7% deaths. Table 1 summarize foodborne illness, hospitalizations and deaths caused by both known and unknown pathogens. *Salmonella* and *Campylobacter* accounted for 26% and 17% hospitalization, respectively.

The Food Standard Agency (FSA) estimates that as many as 5 million people are affected by foodborne illness every year. In 1998, there were 100,000 confirmed cases of food poisoning and around 200 deaths, and in the same year 23,420 and 58059 cases of Salmonella and *Campylobacter* were recorded respectively. These cases represent almost half of the reported food poisoning cases in the UK. Over the last 10 years, the incidence of *Salmonella* hovered around 30,000, peaking in 1997; just under half of the cases were *S. Enteritidis*, commonly isolated from poultry and eggs. In 1999 there were 54,994 cases of *Campylobacter poisoning* reported, and more than two thirds of fresh chicken obtained from leading supermarkets in the UK were infected with Campylobacter *jejuni*. (http://www.ifis.org./forum/april 2000/food-poisoning.html). In the UK, 180,000 animals infected with Bovine Spongiform Encephalopathy (BSE) were destroyed between the period of 1996-2000. Nineteen countries have reported endemic BSE cases and the disease is no longer confined to the European Community, a case of BSE have being reported in a cattle herd in Japan. In human populations, exposure to the BSE agent has being strongly linked to the appearance in 1996 of a new transmissible spongiform encephalopathy of humans called variant Creutzfeld-Jakob Disease (vCJD). As of January 2002, 119 people have developed vCJD, most are from the UK but some cases have being reported from France (WHO Fact Sheet, January 2002).

In Europe, the incidence of food poisoning has being steadily increasing since 1985. More than 30,000 investigated outbreaks involving a total of 391,383 cases have being reported by 42 European countries to the WHO Surveillance Program for Control of Foodborne Diseases in Europe from 1993-1998. The causative agents were identified in approximately 23,538 outbreaks. *Salmonella sp*. is still the most frequently reported causal agent of the outbreaks in European region, being responsible for 77.1% of outbreaks. Of these, more than one-third were confirmed to be caused by *S. Enteritidis*. Other causative agents identified in the investigated outbreaks included *Staphylococcus aureus* (4%), *Trichinella* (3%), *Shigella* (3%), *Clostridium perfringens* (2%), toxic mushrooms (2%), *Campylobacter* (1%), Viruses (1%) and others (7%). As *Listeria* and *E. coli* 0157 is not notifiable disease in most European countries, it is difficult to determine the incidence of these two organisms. (FAO).

Cholera initially identified in Peru in 1991 with 600,000 cases, rapidly spread to other Latin American countries, and in 1994 caused 112,611 cases and 1,229 deaths. The total number of cases and deaths for 1991 and 1994 were 1,061,188 and 9,989, respectively (WHO 1997 Press Release WHO/58).

In Malaysia, the incidence of food poisoning is shown in Table 2. The incidence of food poisoning increased by 49% from 1988 to 1996. As food poisoning is not a notifiable disease, medical practitioners are not required to report any food poisoning to district health authorities.

Table 1. Food illnesses, hospitalization, and deaths caused by pathogens, U.S annually.

Pathogens	Illnesses	Hospitalization	Deaths
Bacterial			
Bacillus cereus	27,360	8	0
Botulism, foodborne	58	46	4
Brucella spp	**777**	61	6
Campylobacter spp	1,963,141	10,539	99
Clostridium perfringens	248,520	41	7
Escherichia coli 0157:H7	62,458	1,843	52
***E .coli*, non-0157 STEC**	31,229	921	26
E .coli, enterotoxigenic	55,594	15	0
E .coli, other diarrheogenic	23,826	6	0
Listeria monocytogenes	2,493	2,298	499
Salmonella typhi	659	494	3
Salmonella, nontyphoidal	1,341,873	15,608	553
Shigella spp.	89,648	1,246	14
Staphylococcus,food poisoning	185,060	1,753	2
Streptoccus, foodborne	50,920	358	0
Vibrio cholerae, toxigenic	49	17	0
Vibrio vulnificus	47	43	18
Vibrio, other	86,731	65	13
Yersinia enterocolitica	86,731	1,105	2
Bacterial subtotal	4,175,565	36,466	1,297
Parasitic			
Cryptosporidium parvum	30,000	199	7
Cyclospora cayetanesis	14,638	15	0
Giardia lamblia	200,000	500	1
Toxoplasma gondii	112,500	2,500	375
Trichinella spiralis	52	4	0
Parasitic subtotal	357,190	3,219	383
Viral			
Norwalk-like viruses	9,200,000	20,000	124
Rotavirus	39,000	500	0
Astrovirus	39,000	125	0
Hepatitis A	4,170	90	4
Viral subtotal	9,282,170	21,167	129
Known pathogens, total	13,814,924	60,854	1,809
Unknown pathogens	62,000,000	263,000	3,400
Grand total	76,000,000	323,000	5,200

Data from Centre For Disease Control and Prevention (CDC)

Table 2: Incidence of Food Poisoning and Deaths in Malaysia from 1988-96.*

Year	No of outbreaks	No of cases	No of death
1988	65	1643	25
1989	31	1782	2
1990	43	1251	1
1991	47	1094	0
1992	35	960	2
1993	11	1638	1
1994	42	1229	3
1995	55	1438	3
1996	50	3236	0

*Source: Ministry of Health, Malaysia.

Data in Table 3 indicates that food poisoning episodes occurred frequently in both primary and secondary schools followed by other institutions. Data in Table 3 indicates that health authorities investigate outbreaks with large number of cases. The occurrence of food poisoning in these locations reflects on the mode of food preparation, food service and overall hygiene.

Table 3: Cases of food poisoning according to location from 1993-96.*

Location	1993	1994	1995	1996
Primary school	326	364	405	1135
Secondary school	998	576	459	876
Private house	12	8	12	12
Food courts	0	0	16	0
Other institution	226	190	382	792
Ceremonies (weddings)	73	82	164	400
Accidental	8	9	0	21
Total	1638	1229	1438	3236

*Source: Ministry of Health

In my opinion, the incidence of food poisoning is much more higher than reported. Experts believe that individuals will, on the average, experience at least 4 episodes of food poisoning in a year. Thus, the burden of foodborne illness and deaths worldwide may be enormous (Tauxe, 1997).

FOODBORNE AGENTS AND VEHICLES

Food poisonings are caused by microorganisms themselves or their toxins, poisonous plants, poisonous animals, chemicals and allergens. Table 4 describes the various agents responsible for food poisoning and toxifications.

Bacteria cause Seventy to eighty percent of foodborne illnesses. Most of these bacterial pathogens are present in the intestinal tract of animals and humans. Among these bacteria, *Salmonella* serovars and *Campylobacter* are the leading cause of foodborne illness. These organisms are frequently isolated from meat and meat products, poultry, eggs, untreated milk and dairy products and any foods that have undergone fecal contamination.

Table 4: Causative agents of food poisoning.

Bacteria	*Salmonella serovars, Shigella Campylobacter, Aeromonas hydrophilla, E. coli V. cholera, V. parahaemolyticus, V. vulnificus, Yersinia enterocolitca, Listeria spp. Cl. botulinum, Cl. perfringens, B. cereus, Staphylococcus aureus and VRE enterococci*
Moulds	Mycotoxins such as aflatoxins, ochratoxin, trichothecenes, zearaleone, fumonisins, luteoskyrin, and patulin
Viruses	Norwalk & norwalk-like viruses, Rotaviruses, Astroviruses, Enteric coronavirus, Human calcivirus , Enteric adenovirus, Hepatitis A virus and Hepatitis E.
Parasites	*Cryptosporidium parvum, Giardia lamblia, Endamoeba coli, Ascaris, Taenia , Cyclospora and Toxaplasma gondii*
Poisonous animals	Consumption of shellfish and fish, which have consumed toxic dinoflagellates, tetradoxoin from puffer fish.
Chemicals	Pesticides, herbicides, heavy metals, growth promoters such as anabolics and antibiotics.

Human enteric viruses are increasingly recognized as important causes of foodborne illness. The most common types of foodborne viral disease are infectious hepatitis due to hepatitis A virus and acute viral gastroenteritis associated with Norwalk agent and other related small, round-structured gastrointestinal viruses. Rotavirus, some adenovirus and hepatitis E virus are important causes of waterborne disease outbreaks, particularly in developing countries. Foodborne outbreaks, associated with human enteric viruses, are usually due to consumption of raw or undercooked shellfish contaminated with feces or ready-to-eat products contaminated by infected food handlers.

Mycotoxins are secondary metabolites produced by fungi of various genera when fungi grows on agricultural products before or after harvest or during transportation or storage. Some fungi such as *Aspeigillus* spp., and *Penicillium* spp. can invade grain after harvest and produce mycotoxins, while others such as *Fusarium* spp., typically infest grains and produce mycotoxins before harvest. In some circumstances, *Aspergilli* can grow and produce mycotoxins before the crop is harvested. Mycotoxins are regularly found in animal feed ingredients such as maize, sorghum, rice meal, cottonseed meal, groundnuts, legumes, wheat and barley. Most of the mycotoxins are relatively stable compounds (they are not destroyed by feed processing) and may even be concentrated in screenings. Various animals species are able to metabolize mycotoxins id different ways and their residues can be found meat, visceral organs, milk and eggs. Mycotoxins may be carcinogenic, estrogenic, nephrotoxic, dermonecrotic or immunosuppressive.

Parasites usually account for less than 5% of the total incidence of foodborne diseases. Parasites are usually present in the intestinal tracts of animals and humans. Animals or humans excrete these parasites in feces in the form of cysts or oocytes which are relatively resistant to the environment. Transmission is through the oral-fecal route, person to person contact or contamination of fruits and vegetables and water by feces containing cysts or oocytes.

Table 5 describes the major bacterial pathogens and foods that frequently cause foodborne illness. *Salmonella, Campylobacter jejuni* and *E. c*oli 0157 are carried by livestock and are principally transmitted to foods by fecal contamination. *C. jejuni* accounts for an estimated 2 million cases of foodborne illness annually in the USA, with poultry and unpasteurized milk as its principal vehicles (Mead *et al.*, 1999). *Salmonella* causes an estimated 1.3 million cases of foodborne illness annually, with eggs, poultry, beef, pork, fruit and vegetables as primary vehicles. *E.coli* 0157 causes an estimated 73,500 cases of infection in the United States annually. Its principal vehicles of transmission are beef, fruits, vegetables, water and contact with cattle (Doyle *et al.*, 1997; Griffin, 1998). These pathogens are present in the intestinal tract of apparently healthy poultry and livestock. Fecal contamination of hides, feathers and skin occurs during poultry and livestock production and slaughter. The contamination can be carried further during processing. *Listeria monocytogenes*, accounts for approximately 30% of the foodborne deaths in the United States (Mead *et al.* 1999) and is associated with cheeses made from unpasteurized milk, ready to eat foods and pate.

Bean *et al.* (1997) estimated that in the US, 0.7 to 2.1 % of all outbreaks, approximately 1% of all cases, and up to 13.3% of food-related deaths are due to the consumption of contaminated shellfish, although the total number of cases is likely to be underestimated (Wallace *et al.*, 1999). *Vibrio sp.* Such as *Vibrio cholera, V. parahaemolyticus* and *V. vulnificus* are usually transmitted by seafood. These organisms are part of the estuarine micro-flora and have excellent survival capabilities in the marine environment. Among the three, *Vibrio* sp., *V. vulnificus* has being of greater concern since the organism results in a syndrome characterized by gastrointestinal disease followed by primary septicemia, with mortalities approaching 50%.

Table 5: Bacterial pathogens and food vehicles frequently implicated in foodborne disease outbreaks.

Pathogen	Food sources
Campylobacter jejuni or coli	Major: poultry Minor: milk mushrooms, hamburger, water, cheese, pork, shellfish, eggs, cake icing.
Clostridium perfringens	Major: meat, meat stews, meat pies, beef ,turkey and chicken gravies Minor: beans, seafood
Escherichia coli 0157:H7	Major: beef particularly round beef. Minor: poultry. Apple cider, raw milk, vegetable, cantaloupe, hot dogs, salad bar items.
Listeria monocytogenes	Major: soft cheese, pate, ground meat, Minor: poultry, dairy product, hot dogs, potato salad, chicken, seafood and vegetables.
Salmonella*(non-typhoid)*	Major: poultry, meat, eggs, milk and their product. Minor: vegetables, fruits, chocolate, peanuts and shellfish.
Staphylococcus aureus	Major: workers handling foods: meat (especially sliced meat) poultry, fish Canned mushrooms. Minor: dairy products, prepared salad dressing, ham, salami, bakery items, custards and cheese.
Vibrio sp	Major: shellfish Minor: other seafood.

FACTORS CONTRIBUTING TO INCREASE IN INCIDENCE OF FOOD POISONING

Many factors have contributed to the increase in foodborne disease. Industrialization, leading to increased wealth and urbanization, has revolutionalized the food supply system, resulting in mass production and a huge increase in the number of food service establishments and food outlets. Changes in agricultural practices, a growing population susceptible to infectious diseases, changes lifestyles, the emergence of new foodborne pathogens, and a high turn-over rate reported for workers in the food-service industry have contributed to increase in incidence in foodborne diseases.

The epidemiology of foodborne pathogens disease is changing. New pathogens have recently emerged, and some have spread worldwide. Some known pathogens have only recently been shown to be predominantly foodborne, such as *Listeria monocytogenes* and *Campylobacter jejuni*. *Listeria monocytogenes* is considered emerging because the role of food in its transmission had only recently being recognized in pregnant women. Infections with *Listeria monocytogenes* can cause abortion, stillbirth, and in infants and persons with weakened immune system it may lead to septicemia and meningitis.

Traditionally, the food implicated in a foodborne outbreak was undercooked meat, poultry, or seafood, or unpasteurized milk. Over the years this scenario have change, foods previously thought to be safe have become hazardous, for example, outbreaks of salmonellosis have being reported for decades but within the past 25 years, the disease has increased in incidence on many continents. In Western Hemisphere and Europe, *S. Enteritidis* has become predominant strain. Investigation of *S. Enteritidis* related outbreaks indicate that its emergence is largely related to consumption of poultry or eggs. The internal contents of a raw egg have being contaminated with *Salmonella Enteritidis* and caused illness when used in traditional recipes such as eggnog, Caesar salad, lightly cooked eggs in omeletttes and French toast, and even foods one would assume thoroughly cooked, such as lasagna and meringue pie. While cholera is endemic in Asia and Africa, it made its first appearance in South American continent in 1991. In the past, Cholera was believed to be waterborne but recent outbreaks have demonstrated that cholera can be transmitted through foods. In Latin America, ice and raw or under-processed seafood are important epidemiological pathways for cholera transmission.

Other foodborne pathogens are considered emerging because they are new microorganisms or because the role of food in their transmission has been recognized only recently. Infection with *E.coli* 0157 was first described in 1982. Outbreaks of infection, generally associated with beef, have being reported in Australia, Canada Japan, United States, and in various European countries and in South Africa. Outbreaks have also implicated alfalfa sprouts, unpasteurized fruit juice, lettuce, game meat and cheese curd.

BSE, a fatal, transmissible neurodegenerative disease of cattle, was first discovered in the United Kingdom in 1985. At present time, 19 countries have reported endemic BSE cases and the disease is no longer confined to the European Community; a case of BSE has been reported in cattle in Japan. In human populations, exposure to BSE agent has lead to appearance in 1996 of a new variant Creutzfeldt-Jakob Disease (vCJD). As of January 2002, 119 people have developed vCJD, most are from the UK but five cases have been reported from France.

THE GLOBALIZATION OF THE FOOD SUPPLY

Globalization of the world's food supply has contributed to changing patterns of food consumption and foodborne illness. Global food trade is likely to increase due to expected increases in global income levels; improved transportation networks, growing populations requiring greater quantities of nutritious and safe food.

Globalization of food supply means that new food safety risks would be introduced in to countries (for example, emerging pathogens), previously controlled risks would be re-introduced into countries (for example, cholera outbreaks in Latin America; recent outbreaks of BSE and Foot and Mouth Disease), and contaminated food would be spread across grater geographical areas and cause illness worldwide. Although global sourcing provides economic benefits and wider selections for consumers would improve nutrition world wide, however, in terms of disease control programs, globalization minimizes geographical barriers to emerging as well as traditional pathogens.

Global sourcing could inadvertently introduce pathogens into new geographical areas; for example, Vibrio *cholera* was introduced into waters off the coast of southern USA when a cargo ship discharged contaminated ballast water in 1991. Similar mechanism might have been responsible for the introduction *V. cholera* in Latin America in 1991. A large outbreak of *Cyclospor*a occurred in North America in 1996-97 was linked to contaminated raspberries imported from South America.

The US Public Health Service's report, Healthy People 2010, states that "an increasing amounts of the food eaten in most countries originates in other countries. Diverse methods of and standards for growing and processing agricultural products and different frequencies and types of gastrointestinal infections in food workers in different regions increase the possibility of food contamination and the range of pathogens expected"(http://: www.healthypeople.gov).

TRANSPORTATION

Advances in transportation technology have greatly facilitated trade of perishable food products by reducing delivery time, maintaining product quality, reducing shipping costs and delivering perishable products purchased thousand of miles away with no substantial loss of freshness and quality, and at lower and lower costs. Information technology and sophisticated tracking systems such as Global Positioning Systems have enable shippers to track their cargo around the world electronically.

Innovations in packaging such as active and intelligent packaging technologies together with Modified Atmosphere Packaging(MAP) are used to extend shelf life, improve safety and improve sensory properties of packaged foods which have further facilitated the transportation of foods over longer distance. There are inherent risks associated with these packaging technologies as under certain circumstances the microenvironment might change which may allow for the selection and proliferation of certain pathogens. For example, recent studies have shown that C. *botulinum* can grow and produce toxin in products such as MAP pizza and English-style crumptets, while the products remain organoleptically acceptable (Daifas *et al*. 1999a, b). Low concentration of CO_2 (less than 10%) used in MAP of some products may inhibit the natural micro-flora and increase the growth rate of *L. monocytogenes*. Combined with storage at refrigerated temperature, which can select for *L. monocytogenes*, a low- CO_2 MAP environment may pose a food safety concern.

Transport of livestock over long distance presents opportunities for dissemination of pathogens. Animals acquire pathogens from the environment where they are raised, feedstuffs and co-mingling of animals from sources. The animals can also readily transmit these pathogens among themselves, once they are transferred from the production environment to the transportation system. Even under the best of conditions, transportation produces measurable stress upon live animals that may have several physiological effects on the live animal and may ultimately impact food safety. Transportation of animas may increase fecal shedding containing potential pathogens such as *salmonella*. The increase in shedding can contaminate the trucks or trailers, and potentially increase the population of foodborne pathogens in and on many of the animals within the truck or trailer. At the slaughtering pens, further co-mingling of animals from different sources is going to increase the opportunity for the spread of pathogens among the animals.

INTERNATIONAL TRAVEL

International travel have increased dramatically during the 20th century. 5 million international tourists arrival were reported world wide in 1950 and the number is expected to reach 937 million by 2010 (IFT, 2000). International travelers may become infected by foodborne pathogens that are uncommon in their countries. It is estimated that about 90% of all cases of salmonellosis in Sweden are imported. In 1992, an outbreak of cholera caused 75 illnesses among international airline passengers, 10 persons were hospitalized and one died (Eberhart-Phillips *et al.*, 1996). *V. Cholera* 0139 was introduced into Malaysia for the first time in 1997 by a tourist returning from India. Pathogens also may be carried home and infect family members and others close personal contacts (Finelli *et al.*, 1992).

MICROBIAL ADAPTATIONS

Microorganisms are able to devise mechanisms that assist them in overcoming process that are design to limit their growth. Studies have suggested that bacteria may induce hypermutability, which would in turn lead to a microbial population of greater resistance (Buchanan, 1997). Therefore, the exposure of cells to some form of stress may induce and allow the survival of microorganism with unusually high durability to a given inactivation process.

The response to stresses in the food system may play a major role in the emergence of pathogens (Sheridan and McDowell, 1998). Bacteria have evolved elaborate networks for protect against or repair damage caused by detrimental conditions. Bacterial responses to stress are varied and complex, including both structural and physiological changes. For most bacteria, these responses are modulated by specific sigma (s) factors (Grossman *et al.*, 1984; Lange and Hengge-Aronis, 1991) or regulators (Christman *et. al.*, 1989), that direct the activation of specific genes that comprise of regulons (large numbers of coordinatedly controlled genes) and encoded for proteins responsible for cellular protection. The proteins produced in response to stress enhance bacterial survival outside the host, including foods (Cheville *et al.*, 1996, Humphrey *et al.*, 1993, Jenkins, *et al.*, 1988 and Kaspar, 1993, O'Neal *et al.*, 1994). Microbes have two categories of stress responses that are usually referred to as General Stress Response or Specific Stress Response. These two categories of stress responses are regulated by genes that have multiple regulatory elements that are recognized by the distinct machinery which coordinates the general and specific responses.

The general stress response (GSR) regulon is a large group of genes that collectively comprise several different functions that facilitate growth and survival under different conditions, such as osmotic shock, thermal stress, pH stress, oxidative stress, and nutrient depletion (Hengge-Aronis, 1996; Hengge-Aronis, 2000; Lee *et al.*, 1995). The GSR for one stress may induce changes that improves the organism's survival under other stress conditions, a phenomenon known as cross protection. For example, it has been demonstrated in the laboratory media that heat-shocking *Salmonella Enteritidis* (shifting the temperature from 20 to 45^{0}C) results in an approximate 3-fold increase in D-values at a pH of 2.6 and a greater than 10-fold increase when the temperature is raised to 56^{0}C (Humphrey *et al.*, 1993). In this example, the original stress (exposure to heat) increases protection to both heat and acid even when the bacteria had not been previously exposed to low pH. The best example of specific stress response is the heat shock response that is regulated by Sigma factor (σ^{32}), as a primary regulator. Approximately 30 proteins belong to the heat shock regulon. Basal levels of the heat shock proteins are produced at all temperature, but at higher temperatures, the microorganism needs a greater concentration of these proteins to remain viable (Gross, 1996). The general stress response protein rpoS, mediates the survival of *Salmonella* in phagosomal vacuoles (Fang *et al.*, 1992), whereas protease/ chaperone proteins and acid tolerance genes play a role in the intracellular survival of S. *enterica* and *L. monocytogenes* (Buchmeler and Heffron, 1990; Johnson *et al.*, 1991; Rouquette *et al.*, 1996 and Marron *et al.*, 1997). As these molecules facilitate survival in both the food matrix and entry into the host cell, inducing these responses in the food matrix could therefore "prime" the pathogenic microorganisms, increasing their capacity to survive entry into a host cell and establish infection.

Bacteria are capable of adapting to an immediate environmental stress, but the response is temporal, and the genes involved are switched off when the stress is removed. The stress response may be triggered by a single parameter or by several simultaneously causing variations in response. Some stress responses have particular relevance to food processing environment. For example, stress responses to temperature shifts, can affect *L. monocytogenes* attachment to food contact surfaces (Smoot and Pierson, 1998). The cross-protective effect in which exposure to one stress triggers resistance to other stress is a special concern in food processing environments. Mazotta (1999) found that the heat resistance of acid-or salt-adapted, heat shocked, or starved *E. coli* 0157 cells was higher than that of cells grown to exponential or stationary phase under optimum conditions. Similarly, the habitual exposure to reduced water activity increase heat tolerance of *salmonella sp*. (Mattick *et al.*, 2000). The extensive growth of the cold chain have allowed for the selection of pathogens such as *Listeria* that can survive and grow at low temperatures. Studies have shown that *Salmonella* serovars and *E.coli* 0157 can adapt to low pH or high acidic environments. Changes in microbial population can lead to the evolution of new pathogens, development and acquisition of new virulent traits by old pathogens, development of antibiotic resistance that might make a disease more difficult to treat, or to changes in the ability to survive in adverse environmental conditions

CHANGING DEMOGRAPHICS

Changing demographic characteristics of consumers affect the number of cases of foodborne illness. The ability of the pathogen to cause disease depends very much on the host's health, age, gender, physical and physiological status. Susceptibility to infectious disease is the inability of the host's body to prevent or overcome invasion by pathogenic microorganisms. Susceptibility to infection is increased by conditions that alters the host's defenses and suppress the function of the immune system. Altered host's defenses and immunosuppression can be caused by an infection, another disease, aging, poor nutrition and underlying chronic diseases. Quality health care and nutrition have contributed tremendously to increase in life expectancy and this has led to an increase in the elderly population at a much faster pace. The elderly usually have a compromised immune system due to underlying chronic diseases such as diabetes, hypertension, cancer and chronic diseases of the bowel. Besides the elderly, there is another of the population that is immunocompromised due to HIV, hepatitis, alcoholism, drug abuse and chemotherapy among cancer patients and use of immunosuppressive drugs n organ transplantation. Incidence of *Salmonella* and *Campylobacter* infections among HIV patients were 19 –94 times compared to the general population (Celcum *et al.,* 1987; Greunewald *et al.*, 1994; Sorvillo *et al.,* 1994). In addition, 16% of *Campylobacter* infections and 44% of *Salmonella* infections resulted in bacterimia in these compromised patients, much higher rates of severe disease than occurred in the general population.

Infants and pregnant women are also at greater risk of acquiring foodborne infections as a result of immature immune system and altered immune system, respectively. In developing countries reduced immunity due to poor nutrition, render people especially infants, children and the elderly, more susceptible to foodborne infections.

CHANGES IN LIFESTYLES

Changes in human behavior such as food consumption, food handling and preparation have contributed to the increase in the incidence of food poisoning. In the United States of America, food service outside the home is big business, with sales of more than US$375 billion (Table 6) and nearly 14.3 million employees. During the period of 1998-99, Americans spend US$788.6 billion on food, out of this US$ 374.7 billions were spend eating away from home and US$ 413.9 billions on food at home (Clausen, 2000; Ellitzak, 2001.) This means that almost 50% of the food budget was spend on food consumed away from home. In Malaysia, fast food industry is worth more than two billion ringgit with almost 2000 outlets and employing thousands of workers. Studies show that more and more people are not preparing food at home. They either eat at food service establishments or buy back ready to eat food and eat at home with minimum preparation. In many countries, the boom in food service establishments is not matched by effective food safety education and control. Unhygienic preparation of food provides ample opportunities for contamination, growth, or survival of foodborne pathogens.

Eating outside the home in restaurants and other foodservice venues have been identified as a risk factor for certain foodborne diseases (Friedman *et al.* 2000). In the 1990s, food eaten outside the home accounted for almost 80% of reported foodborne illness outbreaks in the United States (Beath *et al.*, 1996). The most common causes of food poisoning in food service establishments are food handling behaviours such as inadequate hand washing, unsafe storage temperatures that permit the growth of low levels of pathogens, incomplete cooking of potentially hazardous foods, and cross-contamination of fresh and cooked foods. In a nationwide survey, in the United States, an estimated 37% of food handlers did not wash hands after handling raw meat (Alterkruse *et al.*, 1995).

Table 6: Food spending both at and away from home in the USA.

Expenditures	**1990**	**1996**	**1997**	**1998**	**1999**	***Percent* Change 1990-99**
	— — — — — —	— *Billion*	*Dollars* —	— — — —	— —	
Total food and beverages	638.4	780.9	817.7	842.0	884.7	5.1
Total food (excluding alcohol)	565.4	697.1	729.7	751.5	788.6	4.9
At –home food	316.8	376.5	390.5	398.9	413.9	3.8
Away-from home food	248.7	320.6	339.2	352.6	374.7	6.3

Clausen, 2000

According to Bean *et al.*, (1997), the transmission of 50-95% of confirmed viral foodborne disease outbreaks are attributed to human handling. There is epidemiological data supporting the transmission of *Salmonella* and *Campylobacter* with uncooked poultry in food service settings (D'Aoust, 1989; Harris *et al.*, 1986; Hopkins *et al.*, 1984).

Changes in food consumption habits as a result of urbanization, changing lifestyles and increase in per capita income have also contributed to the increase in incidence of food poisoning. In the United States from 1970 to 1994, consumption of fresh fruits and vegetables increased by 50% (BC/USDC, 1996) and this may have contributed to a series of foodborne outbreaks from 1990–97, associated with such foods as sliced cantaloupe (Reis et al., 1990), green onions (Cook *et al.*, 1995), unpasteurized cider (Besser *et al.*, 1993), freshly squeezed orange juice (Cook *et al.*, 1996), lettuce (Ackers *et al.*, 1996), raspberries (Herwaldt, 1997), alfalfa sprouts (Mahon *et al.*, 1991), sliced tomatoes(Wood *et al.*, 1991) and parsley (CDC, 1999). The dietary shift toward increased consumption of chicken may have contributed to the high incidence of *C. jejuni* infection (Friedman *et al.*, 1992).

The urban population in developing countries will double to nearly 4 billion by 2020. Population and income growth will raise demand for food in developing countries. Limited resources may constrain food production in some developing countries, unless agricultural productivity rises, developing countries are likely to rely on imports to partly satisfy their demand. In urban areas, due to increase in income, eating habits have also changed, for example, urban population consumed more meat while the rural population relies on tubers and cereals. Demand for more meat will indirectly result in increase in demand for more cereals (for animal feeds) than based on direct cereal consumption. Americans in 2001, consumed 97lbs of poultry meat and 67 lbs of beef compared to 34 lbs of poultry and 80 lbs of beef in 1970. This and other changes in consumption patterns brought about by urbanization can significantly affect the global food supply, markets and trade.

CHANGES IN INDUSTRY AND TECHNOLOGY

The trend towards greater geographical distribution of products from large centralized food processors carries a risk for dispersed outbreaks. When mass-distributed food products are intermittently contaminated or contaminated at a low level, illness may appear sporadic rather that part of an outbreak. Mass processing of foods and transport of food over long distances increases the risk of outbreaks of foodborne disease. Transportation of agricultural produce, live animals and animal products and processed foods over long distances has also contributed to the increase in the incidence of foodborne disease. The trend towards greater geographic distribution of products from large centralized food processors carries a risk for dispersed outbreaks. When mass-distributed food products are intermittently contaminated or contaminated at a low level, illness may appear sporadic rather that part of an outbreak. Mass processing of foods and transport of food of long distances increase the risk of outbreaks of foodborne disease.

TRANSMISSION OF FOOD BORNE DISEASES

In the past, central challenge of foodborne disease lay in preventing the contamination of human food with sewage or animal manure or of preventing spoilage. Now, the challenge is to prevent contamination of food by these pathogens, during slaughter and processing, at the point of sale, or in the home. The food production chain has become more complex, providing greater opportunities for contamination and growth of pathogens. Many outbreaks of foodborne diseases that were once contained within a small community may now take on global dimensions.

SOURCES OF CONTAMINATION

Contaminants are introduced into the food supply at numerous points along the way from **FARM TO TABLE.** Food animals and their manures can carry human pathogens, without any clinical manifestations. Likewise, fresh fruits and vegetables, and grains can harbor pathogens or mycotoxins without any discernable loss of quality. Table 7 describes various sources of pathogenic microorganisms and opportunities for the contamination of fruits and vegetables in the food chain.

Foodborne pathogens, viruses and parasites are present in the intestinal tract of food animals, humans and environment. Although these pathogenic organisms are widely distributed in the environment, their primary habitat is the intestinal tract of animals and human. These pathogenic organisms are able to cause foodborne illness because they are able to survive in extraenteral environment under harsh conditions. Fig 1 describes simplified pathway for the dissemination of pathogenic organisms between animals, marine life (seafood), human and plant foods and vice versa. Fig 2 provides a comprehensive description on the dissemination of pathogenic microorganisms.

Table 7: Sources of pathogenic microorganisms on fresh fruits and vegetables.*

Preharvest	Feces Soil Irrigation water Water used to apply fungicides, insecticides Green or inadequately composted manure Air (dust) Wild and domestic animals (including fowl and reptiles) Human handling
Postharvest	Feces Human handling (workers, consumers) Harvesting equipment Transport containers (field to packing shed) Wild and domestic animals (including fowl and reptiles) Insects Air (dust) Wash and rinse water Sorting, packing, cutting, and further processing equipment Ice Transport vehicles Improper storage (temperature, physical environment) Improper packaging (includes new packaging technologies) Cross-contamination (other foods in storage, preparation, and display areas) Improper display temperature Improper handling after wholesale or retail purchase

*Adapted from Beauchat (3)(1996)

Humans become infected with foodborne pathogens by consuming contaminated animal products such meat and meat products, milk and dairy products, poultry and poultry products and eggs. These products become contaminated during the slaughtering process in the abattoir or processing plants. Soil and water resources such as rivers, lakes, estuaries, ponds and coastal areas are contaminated by untreated animal manure, human feces and sewage. The widespread occurrence and use of animal manure as fertilizer is a growing environmental concern, because it contaminates water for drinking, irrigation, aquaculture and recreation farm equipment and buildings. In the United States, cattle, hogs, chickens and turkeys produce an estimated 1.36 billion tons of manure annually (EPA, 2000), with greater that 90% attributed to cattle. Each year livestock create an estimated five tons of animal manure per person living in the United States, meaning the amount of animal is 130 times greater than the amount of human waste produced. Many of the most prominent pathogens such as *Campylobacter, Salmonella, E.coli 0157, Clostridium perfringens* are carried by livestock and are principally transmitted to foods by fecal contamination.

Figure 1: An overview of transmission of foodborne pathogens.

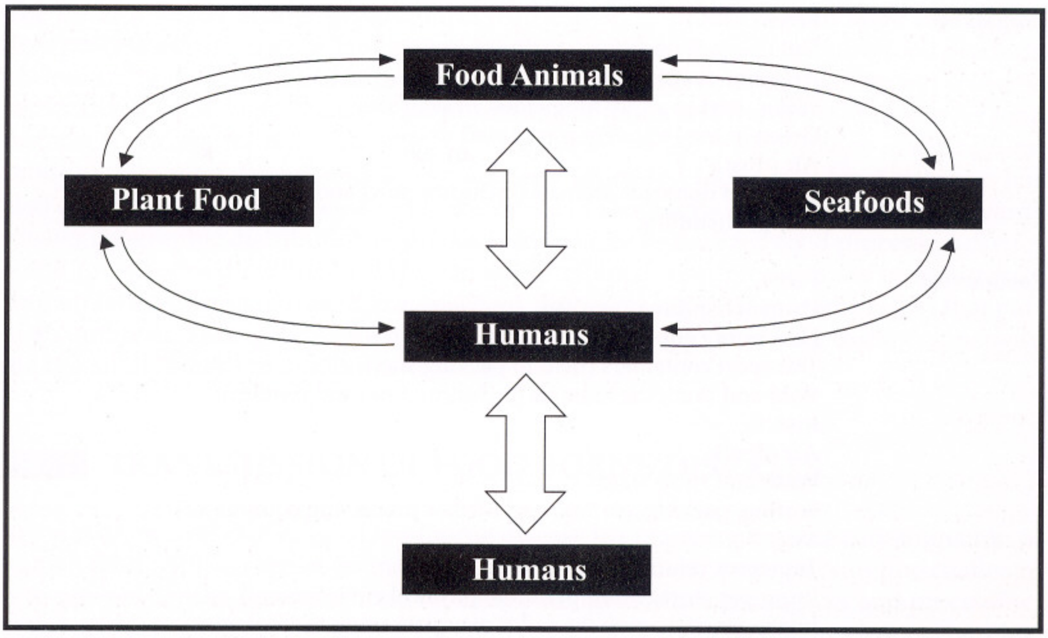
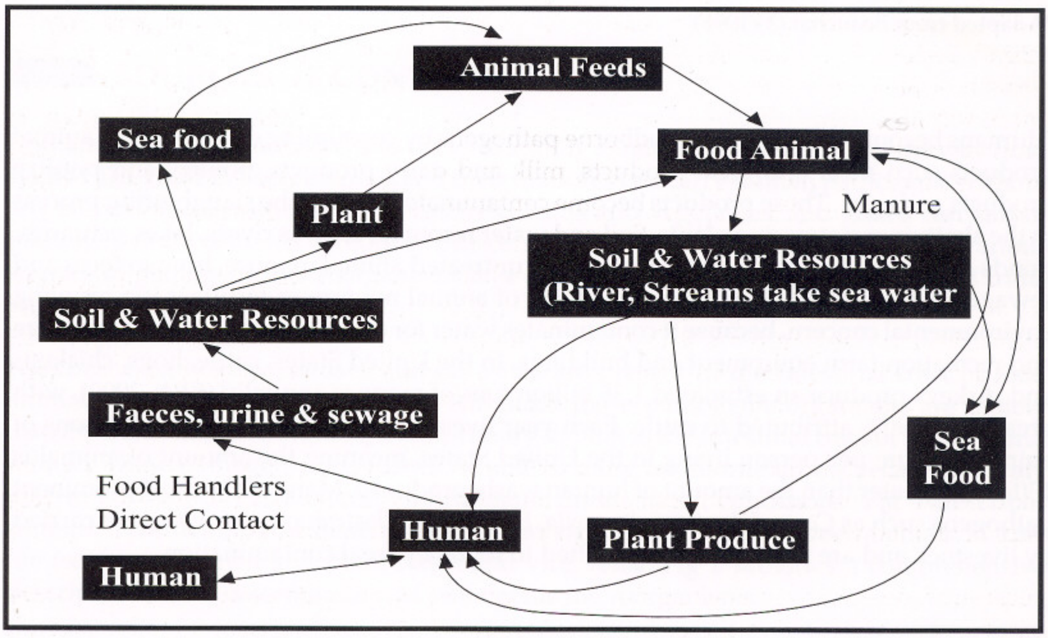


Figure 2: Routes for spread of foodborne pathogens



WATER

Water obtained from different sources can also be an important source of contamination. Agricultural crops such as grains, fruits and vegetables cultivated on soils contaminated with manure and irrigated with these water resources will definitely contaminate the crops. These crops will be a source of pathogens for both humans and animals (converted to animal feeds). Contamination of water resources with untreated manure, human feces and sewage will ultimately contaminate marine life and seafood. Recent evidence of foodborne disease outbreaks associated with the consumption of fresh produce has prompted some to consider the role of contaminated irrigation and surfaces run-off waters as source of many pathogenic microorganisms that contaminate fruits, vegetables and marine life. Irrigation water containing raw sewage or improperly treated effluents from sewage treatment plants may contain Hepatitis A, Norwalk virus, or Enteroviruses (Beuchat, 1996; Beuchat and Ryu, 1997). *Listeria* sp. and pathogenic organisms have been reported in sewage.

Present day, modern and intensive farming practices have also contributed significantly to dissemination of pathogens by direct contact. Livestock densities on farms have increased tremendously without the concomitant increase in staff to monitor and ensure hygiene. The potential dangers of cross-infection and cross-contamination are greatest within the poultry-broiler and swine industry, where highly intensive systems of breeding, rearing, processing and production of feeds (integrated farming) have evolved. The stress during transport from rearing farms to the processing plants exacerbates the secretion of pathogens and cross-infection. In broilers, transmission of certain pathogens, for example, *Salmonella,* can be vertical (transovarian) from grandparent birds to breeding stock, and production flocks, while horizontal within individual flocks. New strains of pathogens may be introduced via imported breeding stock or contaminated feed, or less frequently from vermin or the environment (Rangarajan *et al.*, 2000). Distribution networks have become more complex, which further complicates the situation, as pathogens rapidly adapt to new, adverse environmental conditions, allowing them to survive and replicate under extreme conditions involving high and low temperatures, pH, osmotic pressure, and oxygen levels that are inhospitable to most higher forms of life (Jay, 2000; Kushner, 1980).

Animal feeds which are prepared from animal byproducts (inedible offal, bones, blood, feathers, head and neck), fish waste, agricultural waste and waste from food processing industries are also source of pathogens, if these feeds are not processed adequately or stored properly. For example, increased use of ruminant bone and meat meal as feed supplement for cattle appear to have played a role in the emergence of BSE.

The food production chain has become more complex, providing greater opportunities for contamination and growth of pathogens. Many outbreaks of foodborne diseases that were once contained within a small community may now take on global dimensions.

Because of consumer demand and the global food market, ingredients from many countries may be combined in a single dish, which makes the specific source of contamination difficult to trace.

ANTIBIOTICS

Human health is now being threatened by the excessive use of antibiotics in animal feeds. Animals reared in confine conditions are fed feeds containing antibiotics to promote animal health, feed which can be transferred from animals to humans through the food chain and in other ways (Angulo *et al*., 2000). A growing body of evidence from epidemiological and trace back studies indicates that agricultural use of antibiotics play an important role in the emergence of some antibiotic resistant bacteria (Angulo *et al*., 2000). A recent report by the Soil Association, UK found that about 1225 tons of antibiotics are used annually in the UK with 38% of the total being used in humans, 37% for farm animals and 25% for pets and horses. The report also found that tetracyclines use in farm animals has increased by 1500% in the last 30 years (http://www.ciwf.co.uk/pubs/htm).

The WHO stresses that resistant strains belonging to four different bacteria that cause disease in humans have now been transmitted from animals to human. These are *Salmonella*, *Campylobacter*, *Enterococci* and *E. coli* 0157. These bacteria may prove to be resistant, not just to the antibiotics used for animals, but also to similar antibiotics used to combat serious illness in humans. Poultry farmers use fluroquinolone drugs to keep chickens from dying from *E. coli* infection they could pick up from their own droppings. While the drug may cure the *E. coli* bacteria in the poultry, but *Campylobacter* strains present in intestines of the poultry may build up resistance to these drugs. According to CDC, *Campylobacter* is the most common bacterial cause of diarrheal illness in USA, affecting over 2 million persons every year, or 1% of the population. Thus people who consume chicken contaminated with fluroquinolone-resistant strains are at risk because current drugs might not be effective. Risk assessment carried out by the Center of Veterinary Medicine (CVM) in 2000 on the risks of eating chicken contaminated with fluroquinolone-resistant *Campylobacter*, observed that the number of people infected with fluroquinolone-resistant *Campylobacter* from eating chicken rose from an estimated 8782 in 1998 to 11477 in 1999. (http://www.fda.gov./fdac/features/2001/101_chic.html)

The use of antibiotics in animal feeds has also seen the emergence of multi-drug resistant *Salmonella* serovars. In the United Kingdom, the number of *Salmonella* serovars resistant to antibiotics associated with human infection rose from 17% to 31% between 1979/80 and 1989/90, and the proportion of *Salmonella* isolates exhibiting multi-antibiotic drug resistance to ampilicillin, chloramphenicol, streptomycin, sulfonamides and tetracycline increased from 39% to 97% in the same period. *S. Typhimurium* DT104, referred to as "super bug", resistant to ampicillin, sulfa, streptomycin, tetracycline and chloroamphenicol (R-type ACSSuT) is the second leading cause of human salmonellosis in the United Kingdom (Anon, 1996) and the most common *Salmonella* species isolated from cattle (Hollinger *et al*., 1998). In the United States, ACSSuT resistant pattern was present in 28% of 976 *S. Typhimurium* isolates collected nationally in 1995, a substantial increase from 7% in 1990.The incidence of *S. Typhimurium* DT104 has also being reported in Europe and Canada.

Additionally, there is also the problem of transfer of cross-resistance that is if the organism is resistant to one type of fluroquinolone, it is also most likely be resistant to other types of fluroquinolones. Enberg *et al* (2001) in their review on the emergence of Quinolone and Macrolide resistance in *Campylobacter jejuni* and *C. coli* observed that resistance to fluroquinlones in *Campylobacter* increased over the past decade in many parts of the world. They concluded that when quinolones were exclusively used in human medicine, in a number of countries, quinolone resisitant strains of *Campylobacte*r did not evolved in humans. The emergence of quinolone resistant *Campylobacter* concided with or follows the approval of fluroquinolones use in animal husbandry. The approval of fluroquinolones for veterinary use in Europe led to the emergence of antibiotic-resistant *Campylobacter jejuni* strains in humans and chicken population. The prevalence of enrofloxacin-resistant strains of *Campylobacter* in poultry and humans increased from 0.5 to 14% and from 0% to 11% respectively. Similarly, a high prevalence of quinolone-resistant *Campylobacter* was observed from sewage plants receiving effluents from poultry abattoirs.

Antimicrobial resistance is becoming a factor in virtually all hospital-acquired (nosocomial) infections In addition to its adverse effect on public health, antimicrobial resistance contributes to higher health care costs. Treating resistant infections often requires the use of more expensive and more toxic drugs and can result longer hospital stays for infected patients. The Institute of Medicine, a part of the National Academy of Science estimated the annual cost of treating antibiotic resistant infections in the United States may be as high as US$30 billion, over the last 30 years. (http://www.ciwf.co.uk/pubs/).

Vancomycin-resistant enterococci (VRE) were first isolated from sewage treatment plants in Britain and small towns in Germany and later from manure samples from pigs and poultry farms. These bacteria have being transmitted to humans through the food chain in Germany, Norway and the Netherlands. The VRE are of special concern, because they cause illness and death in patients in hospitals settings, especially those who are immunocompromised. Molecular genetic analysis of vancomycin -resistant isolates isolated from the feces of pigs and poultry in Denmark and transposon Tn1546, isolated from humans, suggest that there has been transmission among humans, farm animals and household pets. The emergence of VRE is linked to use of the antibiotic avoparcin , as growth promoter in animal feed. Avoparcin is structurally related to vancomycin and VRE isolates from Denmark and Germany which are cross-resistant to avoparcin and teicoplanin. With the banning of the use of avoparcin in animal feeds, the incidence of VRE has reduced significantly.

ECONOMIC IMPLICATIONS

In addition to human suffering caused by foodborne diseases in terms of death and ill-health, substantial economic costs are involved, affecting individuals and families, industries, health care systems and entire communities. At the national level, epidemics of foodborne disease affect both tourism and trade. Costs associated with food borne outbreaks include: medical costs inclusive of treatment and hospitalization, death, investigation of outbreaks, product recalls and destruction, absenteeism, plant shut down, product liabilities and law suits and consumer confidence and perception.

It is estimated that the costs of much publicized 6 foodborne outbreaks, summarized in Table 8 that occurred during 1995- 2001were almost US$ 20 billion. The Economic Research Service (ERS), United States Department of Agriculture, estimates that medical costs, productivity losses, and value of premature deaths in the U.S. for diseases caused by five foodborne pathogens is US$6.9 billions per year (Table 9). In the United Kingdom, it is estimated that more than 23 million working days are lost each year costing about 1 billion pound sterling (Swalding, 2000. http;//www.ifis.org/forum/april_2000/food_ safety).

Table 8: Costs of much publicized foodborne outbreaks, 1995-2000.

Outbreak	Agent	Year	Country	*Costs	Comments
Bovine spongiform encephalopathy (BSE)	Prion	1996-2000	United Kingdom	6.3	70 people died of CJD; 180,000 animals culled
Food and Mouth Disease	Virus	1999-2000	United Kingdom	13.5	4 million animals culled
Febrile Encephalitis	Nipah virus	1999	Malaysia	0.4	257 cases with 100 deaths; 890,000 pigs culled.
Dioxin contamination	Dioxin	1999	Belgium	0.66	Lead to product recall throughout Europe and many countries throughout the world. About 1,000 farms were sealed in Belgium, tons of foods were destroyed.
Snowbrand milk powder	Staphy. enterotoxins	2000	Japan	0.102	14,000 cases with 80 hospitalizations; 21 plants closed for 40 days
Avian flu	H5N1 Avian Influenza virus	1997-98	Hong Kong	NA	6 deaths and 1.4 million chicken culled
Total				20.96	

*US$ in billions

When cholera broke out in Peru in 1991, over US$700 million were lost in fish and fishery products. In the three months following the start of the epidemic, US$ 70 million were lost due to closure of food service establishments and a decrease in tourism. The global value of international trade in agricultural products and commodities was estimated at US$ 381 billion in 1993.

Highly publicized foodborne outbreaks may undermine consumer confidence in the safety of foods leading to lasting changes in their perceptions and their purchasing patterns. In 1996, Cyclspora outbreaks in the United States and Canada caused 1,465 illnesses (Herwaldt *et al.*, 1997). Initially Californian strawberries were erroneously implicated, and this caused US$20- 40 million lost in strawberry sales (Powell, 1998). In 1997, CDC established that raspberries from Guatemala was the likely vehicle, which lead to suspension of raspberries imports from Guatemala. The ban on Guatemalan exporters and workers suffered $10 million in losses. The U.S. government lifted the ban in 1998, but the demand for Guatemalan raspberries is only one third of the original exports. Only six Guatemalan raspberry farmers remain in business, down from the 1996 estimates of 85 farmers before the first outbreak (Calvin *et al.*, 2000).

In 1996, sales of beef products in the United Kingdom fell by 40%, following the announcement that beef was implicated in the transmission of BSE. Household consumption of beef dropped by 26% within a month after the announcement (Atkinson, 1999). Exports of beef, beef products and live animals were severely affected. In Germany, outbreaks of BSE caused beef consumption to fall by 75% (Reuters, 2001). Dioxin contamination of animal feeds had serious repercussion on the Belgian economy. There was sharp decline in meat, egg and milk production. The Belgian swine industry suffered when tests results confirmed dioxin contamination of swine on some farms (FAS, 1999). Contaminated farms were depopulated and the swine was destroyed. On the other farms, stables of piglets and slaughter hogs become overpopulated because of reduced demand, limiting stable space, adding unnecessary feed costs, and prohibiting fatteners from buying piglets and starting new fattening cycles (FAS, 1999). Dioxin also caused world- wide fears and led to product recalls from supermarket shelves in many countries that imported not only from Belgium but also other European countries.

According to a 1999 WHO report (http://www.who.org/fsf/fctshtfs.htm). foodborne illness in emerging economies put unnecessary strain on struggling health systems. In addition, the presence of pathogens or other contaminants in foods exported from a developing country can adversely affect development of export-oriented sustainable agriculture. If contaminated exported foods lead to outbreaks of illness or even rumors about such outbreaks among trading partners, it may be difficult for exporting countries to recover their markets.

Food safety problems hurt developing countries by hindering their economic development. Food exports, an important source of foreign exchange and revenue are refused if they do not meet the standards of importing countries resulting in loss of jobs in the food and agriculture industries of developing countries. Productivity suffers in all sectors because so many workers fall ill, international tourism cannot achieved its full potential.

Table 9: Estimated annual costs due to selected foodborne pathogens, 2000

Pathogen/ Bacterial	Estimated annual foodborne illness			Costs
	Cases	Hospitalizations	Deaths	
	Number			Dollars (Billion)
Campylobacter spp	1,963,141	10,539	99	1.2
Salmonella	1,341,873	15,608	553	2.4
E. coli 0157	62.458	1,843	52	0.7
E. coli non-0157 STEC	31,229	921	26	0.3
Listeria monocytogenes	2,493	2,298	499	2.3
Total	3,401,194	31,209	1,229	6.9

Source: Economic Research Service, USDA

CURRENT ISSUES IN FOOD SAFETY

Emerging pathogens

Rapid expansion food of the service industry, changing life styles and demographics, changing food habits, demand for prepared and ready to eat foods, global food market, technological innovations resulting in centralized mass processing, production, distribution and retailing and extensive use and reliance on the cold chain has contributed to the emergence of new pathogens. These transformations have brought about changes in microbial ecological niches resulting in selection and adaptation of pathogens as a result of ever-changing food-microbial environment. The emerging pathogens give rise to diseases that are far more serious than the uncomfortable but relatively temporary inconvenience of diarrhea and vomiting, which are the most common symptoms of so-called food poisoning caused by traditional pathogens such as *Salmonella, Bacillus. cereus, Staphylococcus aureus, Clostridium perfringens,* and *Vibrio parahaemolyticus.* The emerging pathogens such as *Listeria monocytogenes,* Enterohaemorrhagic *E. coli 0157, Campylobacter fetus ssp. fetus* and *vibrio vulnificus* can cause infections that can result in very serious immediate consequences, such as spontaneous abortions, as well as long-lasting conditions, such as reactive arthritis, Guillsin-Barre syndrome(the most common cause of acute paralysis in adults and children), and hemolytic uremic syndrome (HUS), which can lead to kidney failure and death, particularly in young children.

Salmonella

Salmonella, a leading cause of food poisoning in many countries around the world. In England and Wales, during the last ten years, incidences of Salmonella have hovered around 30,000 cases per year. In the United States of America, it is the second leading cause of bacterial food pathogens. There are over 2000 serovars of *Salmonella*, these serovars belong to *Salmonella enterica.* The other species of *Salmonella* are *Salmonella typhi, Salmonella paratyphi* and *Salmonella choleratris*. Serovars of *Salmonella enterica* causes gastroenteritis and *S. typhi* and *S. paratyphi* causes enteric fever. *S. Cholera-Suis* causes an invasive systemic disease.

Although there are 2000 serovars of *S. enterica*, the predominant serovars causing gastroenteritis are *S. Enteritidis* and *S. Typhimurium* especially *S. Typhimurium* DT 104. *S. Enteritidis* is responsible for almost 50 % of foodborne salmonellosis. Poultry products and eggs are the principal vehicle of transmission of *Salmonella*. In 1994, the UK Public Health Laboratory reported that 41 and 33 % of frozen and chilled chicken produced in the UK were contaminated with *Salmonella*, respectively. The report also observed that the incidence of *Salmonella* decreased from 80% in 1979 to 30-40 % in 1994.

S. Typhimurium DT104 is primarily associated with cattle but it has spread to other food animals, such as pigs, sheep and poultry. *S. Typhimurium* DT104 is now the most commonly reported phage type of *S. Typhimurium* in England and Wales. *S. Typhimurium* DT104 is resistant to many of the commonly used antibiotics, including ampicilin, chloroamphenicol, streptomycin, sulphonamides and tetracycline. Strains resistant to these antibiotics (designated as R type ACSSuT) accounts for 58% of all isolates of *S. Typhimurium* DT104. Recent evidence indicate that some of *S. Typhimurium* DT104 strains are also becoming resistant to ciprofloxacin.

The natural habitat of *Salmonella* is the intestinal tract of warm-blooded animals. The organism can exits in the intestinal tract without causing any illness. The major route of *Salmonella* transmission is direct or indirect fecal contamination of foods throughout the food chain.

Most *Salmonella* serovars are to a certain extent resistant to food processing conditions, such as acids, drying, preservatives or surfactants, as they have regulatory mechanisms that enable them to adapt or overcome stress conditions.

In Malaysia, although salmonellosis is not a reportable disease, the incidence of *Salmonella* isolated from human has doubled (Jegathesam, 1984; Jegathesam *et al.*, 1993). The prevalence of *Salmonella* in Malaysia has been reported by a number of investigators (Yee and Ayob, 1994; Son *et al.*, 1995; Rusul *et al.*, 1996, 1998, Arumugaswamy *et al.*, 1994).

In a comprehensive study on the prevalence of *Salmonella* in chicken, Rusul *et al.* (1996) reported that 35.5% (158/445) and 50% (52/104) broiler carcasses obtained from wet markets and processing plants respectively were positive for *Salmonella*. The results are presented in Table 10. In this study, a total of 230 *Salmonella* isolates belonging to 15 serovars were isolated (Table 11). The predominant serovars were *S. Enteritidis* (81/230), *S. Muenchen* (46/230), *S. Kentucky* (33/230), *S. Blocky* (24/230) and *S. Chincol* (12/230). 96.4% of the isolates examined were resistance to at least one antibiotic and 55 % of the isolates were resistant to 3 or more antibiotics. 110 of the isolates harbored plasmids. 3 different plasmid profiles were observed among the 110 isolates (Rusul *et al.*, 1998).

Table 10: Salmonella in broiler production and processing.

Sample type	No. of samples	No. of positive samples (%)
Poultry carcass		
Wet Market	445	158(35.5)
Processing plant	104	52(50.0)
Total	549	210(38.3)
Intestinal content		
Market	54	6(11.0)
Processing plant	44	8(18.2)
Total	98	14(14.3)
Litter		
Broiler farms	40	8(20.0)
Breeder farms	10	2(20.0)
Total	50	10(20.0)
Feed		
Broiler farms	17	0
Breeder farms	6	0
Grand Totals	**720**	**234(32.5)**

Rusul *et al.*, 1996

Table 11: Salmonella serovars isolated from broiler production and processing.

Serovar	Type of sample				
	Poultry carcass		Litter		
	Wet-markets	Processing plants	Broiler farm	Breeder farm	Total (%)*
S. Enteritidis	28	47	5	1	81(35.2)
S. Muenchen	46	-	-	-	46(20.0)
S. Kentucky	31	2	-	-	33(14.3)
S. blockley	19	-	-	-	24(10.4)
S. chincol	12	5	-	-	12(5.2)
S. Newport	9	-	-	-	9(3.9)
S. agona	5	-	-	-	6(2.6)
S. weltevreden	4	1	-	-	4(1.7)
S. hadar	2	-	-	-	2(<1)
S.bovismorbifican	1	-	-	1	2(<1)
S. breadney	1	-	-	-	1(<1)
S. Haifa	1	-	-	-	1(<1)
S. Nagoya	1	-	-	-	1(<1)
S. bardford	1	4	-	-	5(2.2)
S. Lomita	-	-	3	-	3(1.3)
Total	**161**	**59**	**8**	**2**	**230**

* Percent Positive
Rusul *et al.*, 1996

The study also demonstrates that the prevalence of *S. Enteritidis* has increased drastically in a relatively short period. The increase of the incidence of *Salmonella Enteritidis* has attributes to the increase of consumption of poultry and eggs. Intensive poultry farming has lead to establishment of *Salmonella Enteritidis* in poultry farm. A risk assessment model developed by FDA predict that about one in every 20,000 eggs produced are contaminated. The model also predicts the contaminations of eggs will result in 661,000 human illness.

In an ongoing research at the Department of Food Science, Faculty of Food Science and Biotechnology, Universiti Putra Malaysia, *Salmonella* was isolated from 16/43, 8/20, 8/25, and 8/18 samples of Selom (*Oenanthe stolonifera*), Pegaga (*Ceutella asiatica*), Kangkong (*Ipomoea aqualitica*) and Kesum (*Poly gonum minus*), respectively. These samples were obtained from wet-markets in Puchong, Kajang and Sungai Besi. A total of 184 isolates belonging to 30 serotypes were isolated from these 4 different types of condiments.

Results of these two studies suggest that prevalence of *Salmonella* is a serious problem. The diversity of serovars isolated in these studies also reflect on the overall hygienic conditions under which poultry or these condiments are produced. The condiments examined are usually eaten raw; the presence of *Salmonella* on these condiments presents a serious health hazard.

Listeria monocytogenes

Listeria monocytogenes gained prominence in 1985, when it caused miscarriage in pregnant women after consumption of Mexican-style cheese in California. In this incidence, 81 women were affected with 48 deaths (including 19 fetal and 10 neonatal). *L. monocytogenes* maybe present in the large intestines of humans. It is estimated that the fecal carriage rate in various populations of healthy adults range from < 1 % to 21 % (FDA, 2001).

L. monocytogenes is widespread in the environment and has frequently been found in meat, fish, poultry and their products. It is also found on vegetables and it is particularly prevalent in vegetation and grasses.

In developing a Risk Assessment model for *L. monocytogenes* (FDA, 2001), it was identified that dairy products, ranked number one, followed by meat products, then fish products and finally, vegetation. Together dairy and meat products were responsible for 70.8 % of the outbreaks for which a food vehicle was identified. When number of outbreak-associated cases were ranked, meat products were first and dairy products were second. Contaminated meat and dairy products were responsible for 92.4 % of the cases.

Dairy and Ready to Eat (RTE) meat products are most often implicated in *Listeria* outbreaks throughout world. The RTE meat products responsible are frankfurter, pate and pork tongue. The most commonly implicated dairy product was soft (fresh and mould ripened) cheese, especially when the cheese is made from unpasteurized milk.

Data in Table 12 shows the isolation of *L. monocytogenes* in food stored in refrigerators of patients with listeriosis (Pinner *et al.*, 1992).

Table 12 : Isolation of L. monocytogenes in food specimens collected from the refrigerators of patients with listeriosis.

Food Category	No. of positive food (% positive)	No of food tested
Beef	50(36)	140
Poultry	33(31)	108
Pork	26(27)	95
Lunch meat	18(18)	98
Seafood	7(12)	57
Vegetables	72(11)	683
Fruit	5(3)	155
Dairy	9(2)	533
Other*	6(4)	144
Total	226(11)	2,013

*Included bread, pasta, eggs, lamb and miscellaneous anxieties of food.

(Pinner et al., 1992)

In Malaysia, Arumugaswamy *et al*. (1994) examined 234 food samples, consisting 158 and 76 samples of raw and ready to eat foods respectively. The results are summarized in (Table 13). The significant observation in this study was that 22 of the 76 samples of RTE foods were positive for *Listeria monocytogenes*. The detection of *L. monocytogenes* in a high proportion of RTE foods indicate that the community at large has been extensively exposed to *Listeria. L. monocytogenes* was isolated from 3/25 samples of salted fish by Endang *et al.* (1998).

L. monocytogenes causes non-invasive listeriosis with mild flu, the symptom (referred to as listerial gastroenteritis) in healthy individuals and invasive listeriosis in high-risk individuals. The manifestations of invasive listeriosis can be bacteremia, bacterial meningitis, conjunctivitis, central nervous system infection, cutaneous infections, encephalitis, endocarditis, miningoencephalitis, miscarriage, neonatal disease, osteomylitis, peritonitis, premature birth and stillbirth. High-risk individual are pregnant ladies, infants, elderly, individual with impaired immune system, those suffering from chronic disease, such as hepatitis or diabetes.

Studies have shown that *L. monocytogenes* is present in the environment and food in Malaysia. The extent of *Listeria* contamination in food suggest that human listeriosis may be prevalence in the community. It is important for food processors and regulatory agencies to consider the following factors in designing strategies to prevent growth and survival of *L. monocytogenes* commonly found in the environment, including food processing, distribution, and retail environments, in foods, and in the home.

It can grow slowly in many foods during refrigerated storage and this favors selection and outgrowth of *L. monocytogenes* over prolonged storage. It is more resistant than most bacteria to processing condition used to control other foodborne pathogens.

Table 13 : Prevalence of L. monocytogenes in foods

Food	No. of samples	No. of sample positive
Raw foods		
Chicken Portions	32	19(60%)
Chicken Liver	17	10(60%)
Chicken gizzard	18	12(66%)
Beef	12	6(50%)
Fresh pawn	16	7(44%)
Kupang (dried oyster)	3	1(33%)
Leafy Vegetables	22	5(22%)
Bean Sprout	7	6(85%)
Bean Cake	8	2(25%)
Satay (Uncooked)	23	11(48%)
Ready to eat foods		
Satay	39	11(26%)
Squids, prawn, chicken and clams.	27	6(22%)
Cucumber (slices)	5	4(80%)
Peanut Sauces		1(20%)
(Arumugaswamy *et al.* 1994)		

Escherichia coli 0157:H7

E.coli 0157:H7 was first recognized as a human major foodborne pathogen following two outbreaks of gastroenteritis in Michigan and Oregon in 1982, both of which were epidemiologically linked to the consumption of hamburgers (Riley *et al.*, 1983)

In the US, this pathogen has emerged as a major cause of bloody diarrhea and non-bloody diarrhea, causing as many as 62,458 cases with 1,843 hospitalizations and 52 deaths annually (Mead *et al.*, 1999). Its principal vehicles of transmission are beef, fruits, vegetables, water (both drinking and recreational), and contact with cattle (Doyle *et al.*, 1997; Griffin, 1998). Since *E.coli* is present in the intestinal tract of cattle, the pathogen's most frequent origin is direct or indirect contact with cattle manure. Manure can contaminate food when used as soil fertilizer, when it pollutes irrigation water, when cattle defecate near fruits, vegetables or foods of animal origin, and when intestinal contents or manure-laden hides contact carcass during slaughter and processing.

E.coli can survive in manure, water troughs, soil and water at ambient temperature for weeks (Faith *et al.*, 1996; Sargent *et al.*, 2000; Manle, 2000; Rice and Johnson, 2000). *E.coli 0157:H7* strains are able to persists in cattle without causing disease because cattle lack a receptor for the illness-producing Shiga toxin (Pruimboom-Brees *et al.*, 2000).

E.coli 0157:H7 also have been isolated from retail ground beef, pork, poultry and lamb (Doyle and Schoeni, 1987). *E.coli 0157:H7* causes illness such as hemorrhagic colitis, hemolytic uremic syndrome, and thrombotic thrombocytopenia purpura (Karmali, 1989). *E.coli 0157:H7* is able to cause the above-mentioned diseases because it produces Shiga toxins. The organism also encodes for attaching and effacing genes that enables the pathogen to attached and adhere to the epithelial cells and form a pedestal on the epithelial surface upon which the bacteria resides.

E.coli 0157:H7 is able to survive in a low pH environment. This facilitates the passage through the stomach, making it possible for *E.coli 0157:H7* to cause disease at low infection dose (10-100 bacteria). The organism's acid tolerance also allows it to survive within acid food, which was a major factor in the outbreaks of illness traced to unpasteurised apple juice, a product with a pH of approximately 3.5 that usually inhibits the less virulent strains of *E.coli* (Besser *et al*, 1993). Tauxe (1997) reviewing evolution of foodborne pathogen observed that *E.coli 0157:H7* has caused illness through an ever-broading spectrum of foods, beyond the beef and raw milk that are directly related to the bovine reservoir.

Prevalence of *E.coli 0157:H7* has been reported in United Kingdom, Europe, South Africa, Thailand and Malaysia. Son Radu *et al*. (1998) for the first time reported the prevalence of *E.coli 0157:H7* in imported beef in Malaysia. 12 strains of *E.coli 0157:H7* were isolated from 9 of 25 beef samples obtained from retail stalls in Malaysia. Seven of the 12 strains have the ability to produce both Stx1 and Stx2 (Stx, synonymous with verotoxin and Shiga-like toxin) toxins. The remaining five strains were capable of producing Stx2 toxin only. The 12 strains also had the eae gene and a 60-Mda plasmid. None of the 12 strains showed identical antibiograms.

The authors concluded that the differences in antibiogram, plasmid profile, and AP-PCR (arbitrarily primed PCR) suggest that the strains may have originated from diverse sources.

As *E.coli 0157:H7* causes illness in human being, research should be directed in identifying its role in clinical setting. There have been reports that incidence of renal diseases are on the rise, thus it is vital that an epidemiological study be conducted to determined whether there is any correlation between renal diseases in Malaysia and the prevalence of *E.coli 0157:H7* in foods.

FOOD SAFETY MANAGEMENT

The objective of food safety management is to ensure safe food is available from the farm to the table. Food safety involves the interaction of three factors, that is pathogen, host and the environment (external of the food and the food itself as an environment). In developing strategies to manage food safety, an understanding of the pathogen (hazard), host and environment is essential.

Identification and characterization of the hazard should be based on scientific information. Conditions under which the hazard arises, both for the host and the environment should be elucidated based on scientific principles.

A good management system should be able to develop and implement a well conceived strategic approach that quickly and accurately identifies hazards, ranks the hazards by their level of importance, and identifies approach that have the greatest impact on reducing hazards, including strategies to address emerging hazards that are previously unrecognized.

A number of scientific tools are available that can be used to identify, characterize, measure hazards, assess exposure, characterize risk involved with a food (collectively referred to as Risk Assessment) set limits on hazard (Food Safety Objectives, FSO) and identify and manage hazards (HACCP).

Risks assessment has 4 components:

1. **Hazard identification** involves in the identification, characterization, potential health effects and individual risk.

2. **Exposure assessment** describes the exposure pathway and considers the likely frequency and level of intake of the food contaminated with hazard.

3. **Hazard characterization** explores the relationship between the exposure level and the nature of the adverse effects, considering both frequency and severity.

4. **Risk characterization** identifies the likelihood that a population of individuals would experience an adverse health outcome from exposure to food that might contain the pathogen.

Risk assessment provides an opportunity to determine the impact of a particular food safety problem; impact or outcomes of protective mitigation measures and the levels of urgency and controversy surrounding an issue.

Food Safety Objectives (FSO) as defined by (ICMSF, 1997, 2002) is a statement of the maximum frequency and/or concentration of a microbiological hazard in a food at the time of consumption that provides the appropriate level of protection. The advantages of FSO in that, it allows for setting detection limits of hazards after considering their public health outcomes and their potential to grow during processing, storage and distribution. The FSO approach integrates scientific data from risk assessment to set quantifiable standards that address specific public health outcomes.

HACCP

Since an FSO has translated public health goals into quantifiable limits, hazard control and monitoring practices must be developed. HACCP is a management tool used by the food industry to enhance food safety by identifying hazards, critical control points (CCP) in a process (at which the hazard might pose a risk) and implementing preventive measures at certain steps of a process. HACCP is an essential part of implementing a FSO. Through the identification of CCPs, the process and/or product criteria can be translated into process-specific critical limits. Successful HACCP implementation has not being limited to food processing environment. It has being used world wide to improve food safety in food science and retail, and food distribution. For HACCP to be successful, it is important that it should be based on scientific data. HACCP has its limitation in production of agriculture because it is difficult to identify CCPs that are manageable, as it is difficult to identify the source of a hazard and finding an effective control. Thus it can be seen from the above discussion, an effective framework based on science can be developed for the management of food safety.

As HACCP is not suitable for production agriculture, framework or policy or Good Agriculture Practices should be developed. Good Manufacturing Practices should be an integral part of any food safety management initiatives or protocols.

As it has been emphasized, Food Safety Management should be based on good scientific information regarding the pathogen, host and environment, which constitute the integral part of food safety. Scientific information required to formulate food management strategies can be obtained by carrying out surveillance. Surveillance involves the systematic collection of data with analysis and dissemination of results. The objectives of surveillance are: - (i) identify, control and prevent outbreaks of foodborne diseases, (ii) to determine the causes of foodborne diseases, (iii) to monitor trend in occurrence of foodborne disease, (iv) studying the population to track gastro-illness, including trends in requests for health care, food consumption and persuasive preventive measures.

Foodborne disease surveillance can also provide important feedback on the effectiveness of control strategies. Integrating the various surveillance systems such as animal, environmental and human surveillance systems will greatly enhance our understanding of the of foodborne pathogens.

Besides developing effective surveillance system, priority should also be given to developing methodologies to understand the molecular genetics of foodborne pathogen in terms of pathogenicity, molecular mechanism that allow pathogens to overcome control measures and genetic relatedness of pathogens to understand their epidemiology.

As the actions or activities of consumers also play an important part in food safety, education programs and food safety campaigns should be carried out regularly to influence changes in behavior, attitudes, and food consumption patterns.

CONCLUSIONS

Food Safety is an increasingly important public health issue. Governments all over the world are intensifying their efforts to improve food safety. These efforts are in response to an increasing number of food safety problems and rising consumer concerns.

This article presents an overview of food safety in the changing environment. Globalization of food trade, industrialization, demographics, urbanization, increasing population, and strategies to increase efficient food production that is cheap, with optimization of land and human resource to meet the needs of growing population, have created new challenges to ensure food safety. Food safety is an integral part of the food chain, and safety of foods can be achieved if the necessary infrastructure is put in place. Farmers need to be educated on the prudent use of antibiotics, pesticides and insecticides and adopt good agricultural practices. Food processors, manufacturers and retailers need to adopt Good Manufacturing Practices, HACCP and developed good preventive strategies that will prevent contamination of foods and growth of pathogens. The regulatory agencies have to improve the present public health infrastructure by adding new surveillance systems, so that public health practitioners can investigate and respond quickly to foodborne outbreaks. The government and industry should provide funds to carry out fundamental and applied research to understand the ecology of the pathogens, mechanism or strategies that the pathogen possess in overcoming the host; minimal system and controls that are in place to control their growth and survival. Better understanding of foodborne pathogens is the foundation for new approaches to disease prevention and control.

Dr. Jacques Diou (2000), Director General of FAO, addressing the Global Forum on Food Safety in Marrakech, Morocco observed that "Food safety is a shared responsibility of developed and developing countries". With the increasing globalization of trade in food products, health requirements applied by importing countries must seek to protect consumers and not to raise technical barriers to trade. He further urged developed countries to provide developing countries with their technical and financial support. Foodborne illness is a major and complex problem that is likely to become greater a Marrakech problem as we become a global society.

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